

A STUDY OF WELL CONSTRUCTION FOR ARSENIC CONTAMINATION IN NORTHEAST WISCONSIN

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Arsenic has been detected in approximately one third of the private drinking water wells in the Fox River valley of Northeast Wisconsin. Concentrations detected are some of the highest found naturally occurring in the world. Research has indicated that presently 3.5% of the wells in Outagamie and Winnebago counties exceed the current drinking water standard of 50 ppb.

Department of Natural Resources study results indicate the geochemical phenomenon causing the elevated levels of arsenic in groundwater of this region is associated with oxidation of a sulfide-mineralized zone located at the top of the deep sandstone aquifer system. A regional decline in water levels may have exposed this sulfide rich zone to oxidation from air within the open boreholes of water wells extending through this zone. This oxidation process can initiate a chemical reaction similar to acid mine drainage.

Recommendations have been developed for constructing wells within a delineated advisory area. This guidance recommends constructing wells with well casing pipe to extend through the sulfide rich zone. This study compared arsenic concentrations of wells constructed according to the guidance, with wells constructed to traditional construction standards. Additionally, this study examined data to determine if it was better to replace a contaminated well with a new one, or to reconstruct the existing well with a liner.

The results of this study indicate that the guidance gives adequate protection for wells constructed in the arsenic advisory area and that liners are successful at reducing arsenic concentrations, although not as successful eliminating arsenic contamination.

Geology

Quaternary Deposits – Predominantly fine grained tills and lacustrine silts and clays. Minor amounts of sand and gravel deposits are present throughout the area.

Sinnipee Group – Dolomite with a thin shale formation in the middle. The Galena- Platteville formations are massive and regionally acts as an aquitard , yet are good for domestic supply where weathered and fractured.

Ancell Group – St. Peter formation is a fine to medium grained sandstone with a thin silty sandstone formation on top and shale at the base. Thickness is variable in the area.

Prairie du Chien Group – Dolomite with varying amounts of oolitic chert. Thin or absent where the St. Peter is very thick.

Jordan Formation – Fine to medium grained sandstone.

Tunnel City Group - Fine to medium grained sandstone, silty sandstone and glauconitic dolomite.

Elk Mound Group – Very fine to fine grained sandstone and medium to coarse grained sandstone.

Precambrian – Granitic rocks, undifferentiated.

1 The original well on this property was constructed in 1978. It was 6” hole with casing to 44 feet and a total depth of 123 feet. In 1994 the well was sampled and had an arsenic level of 987 ppb. A new well was constructed to the recommended specifications. A 9” hole was drilled to 151 feet. Six-inch casing was installed

to 152 feet. The total depth of the new well was 180 feet. In 1999 declining water quality lead to further investigation. Arsenic levels had again risen to the 1000 ppb level. It is suspected that problems with caving sandstone during the grouting process may have allowed the aggressive water to corrode the casing and contaminate the well. This same problem has been documented at a nearby well. A new 303-foot well with 250 feet of casing has been constructed on the property and has been fine so far.

2 This well was constructed in 1977, with 6" casing to 44' and a total depth of 123'. The contact between the Galena-Platteville dolomite and the St. Peter Sandstone was reported at 75'. In 1978 a packer was installed at 87' to reduce high iron. In 1990 the homeowners reported the water from this well to be an irritant to their skin, have a metallic taste and were deteriorating the plumbing fixtures. The DNR was contacted in 1991 and found that the water had a pH of 2.5

Sample results from 1992 were:

pH = 2.05

As = 4300+ ppb

Cr = 84 ppb

Cd = 220 ppb

Ni = 11000 ppb

Al = 15000 ppb

Co = 5500 ppb

Pb = 400 ppb

A new well was installed in 1993 as a shallow dolomite well with a total depth of 40'. The well continues to produce treatable potable water.

Sample results from that well in 1995 were:

pH = 7.08

As = 5 ppb

Ni = 8 ppb

Pb = ND

3 This well was constructed 1/92 to a total depth of 155' with casing set to 45'. The static water level was 70', which dropped to 94' while pumping. Normal pumping caused the water level to fluctuate across the contact of the Galena-Platteville dolomite and St Peter sandstone, the most concentrated zone of sulfide mineralization.

10/19/93 sample results

pH= 6.4

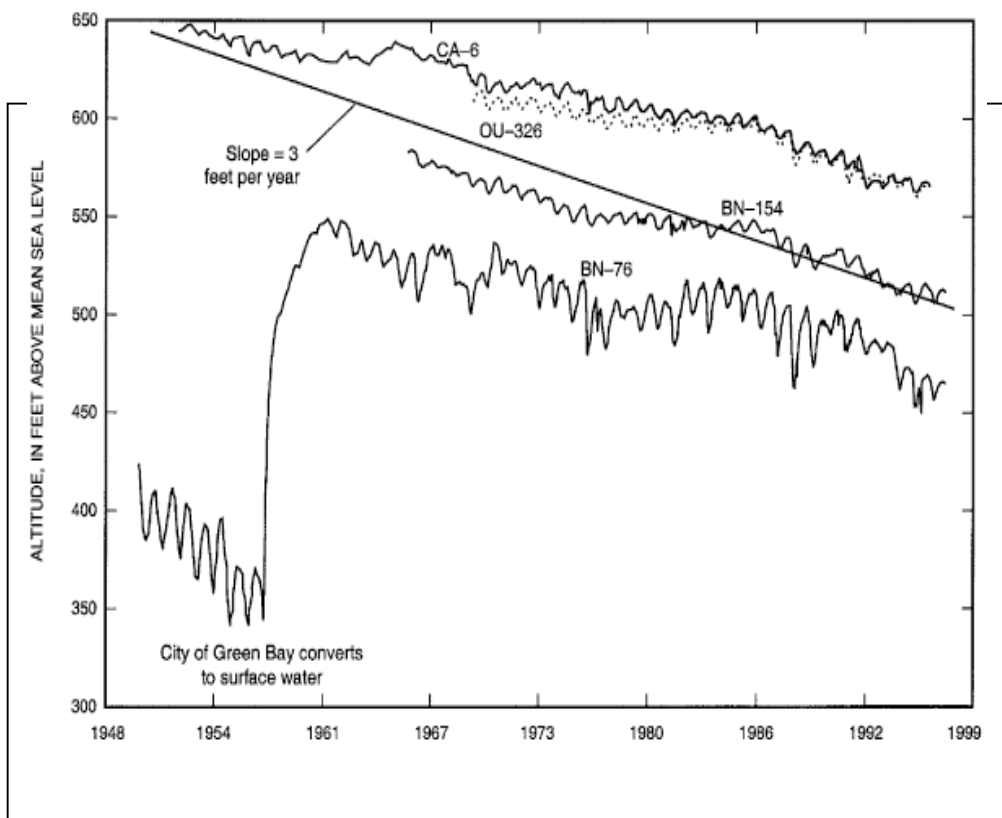
As = 12,000 ppb

11/17/93

As = 15,000 ppb

This well and a neighboring well were reconstructed by drilling deeper, into Cambrian sandstone and grouting in a 4" liner to 290'. Since then all arsenic results have been <5 ppb in one well and range from 1.2 to 6.6 in the other well. Another well right next door was drilled out to 243 feet and a 4" liner was grouted to 153'. Arsenic concentrations in the reconstructed well dropped to 18 ppb, but have been rising and are now in the 200 ppb range.

4 Oxidation of the sulfide minerals is being enhanced due to a large cone of depression caused by Municipal and Industrial pumping in the Green Bay area. As can be seen on this hydrograph, after an



initial rebound in 1957 when Green Bay switched to surface water for a municipal supply, the water levels have been declining at a rate of about 3 feet per year.

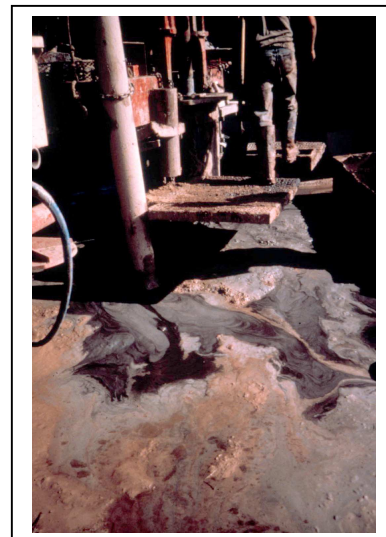
Land-use activities and development of high density housing (sub-divisions) have locally reduced infiltration along with higher water demands have also contributed to declining water levels. As can be seen on the attached well construction reports, two wells were replaced in 1995 for lack of water. The wells developed a problem with arsenic, with reported levels over 900 ppb. The construction reports for the new wells on the same properties indicate static water levels are 30 to 40 feet lower in 1998 than in 1995.

1. Well Location City: DE PERE State: WI Zip Code: 54115 County: BROWN Co. Well Permit No.: September 1, 1995		2. Well Type 1 = New 2 = Replacement 3 = Reconstruction Reason for new, replaced or reconstructed well? DRY WELL	
3. Well Construction Well Completion Date: September 1, 1995 License # 12: 4462 Dates: 09/06/95 to 09/06/95		4. Well Location T-Town C=City V=Village Fire # (If avail.) of HOBART Grid or Street Address or Road Name and Number Subdivision Name Lot # Block # Gov't Lot # or NE 1/4 of NW 1/4 of Section 27 , T 23 N, R 19 E	
5. Well Location Address: 3671 MONROE RD City: DE PERE State: WI Zip Code: 54115 M=Manic. O=OTM N=Non-Com. P=Priv Z=Other K=Non-Pot. A=Anode L=Loop H=Drillhole		6. Well Location High Capacity: FM Well? N Property? N	
7. Well Location (Dr: barn, restaurant, church, school, industry, etc.) Well located on highest point of property, consistent with the general layout and surroundings? Well located in floodplain? N Distance in Feet from Well to Nearest: 1. Landfill 2. Building Overhang 3. Septic or Holding Tank (circle one) 4. Sewage Absorption Unit 5. Nonconforming Pit 6. Buried Home Heating Oil Tank 7. Buried Petroleum Tank 8. Shoreline/Swimming Pool		9. Downspout/Yard Hydrant 10. Privy 11. Foundation Drain to Clearwater 12. Foundation Drain to Sewer 13. Building Drain 1 = Cast Iron or Plastic 2 = Other 14. Building Sewer 1 = Gravity 2 = Pressure 1 = Cast Iron or Plastic 2 = Other 15. Collector or Street Sewer 16. Clearwater Sump 17. Wastewater Sump 18. Paved Animal Barn Pen 19. Animal Yard or Shelter 20. Silo - Type 21. Barn Outlet 22. Manure Pipe 1 = Gravity 2 = Pressure 1 = Cast Iron or Plastic 2 = Other 23. Other Manure Storage Other NR 112 Waste Source 24.	
8. Drillhole Dimensions From To Dia. (in.) (ft.) (ft.) 9.0 surface 62.0 6.0 62.0 223.0		9. Method of constructing upper enlarged drillhole only X 1. Rotary - Mud Circulation 2. Rotary - Air 3. Rotary - Foam 4. Reverse Rotary 5. Cable-tool Bit in dia. 6. Temp. Outer Casing in dia. Removed? 7. Other	
10. Static Water Level 90.0 ft. B ground A=Above B=Below		11. Pump Test Pumping Level 120.0 ft. below ground surface Pumping at 30.0 GPM 1.00 in.	
12. Well Is: Developed? <input checked="" type="checkbox"/> Disinfected? <input checked="" type="checkbox"/> Capped? <input checked="" type="checkbox"/> Depth (feet)		13. Grout or Other Sealing Material From To Dia. (in.) screen type, material & slot size	

Mailing Address 269 ORLANDO DR		City DE PERE	State WI	Zip Code 54115
County of Well Location BROWN		Co. Well Permit No.	Well Completion Date September 23, 1998	
Well Constructor (Business Name) VAN DE YACHT BILL WTR		License # 4462	2. Dates 10/07/98 Rec'd	
Address 3671 MONROE RD		City DE PERE	State WI	Zip Code 54115
M= Munic. O= OTM N= NonCom P= Priv Z= Other X= Non-Pot. A= Anode L= Loop H= Drillhole		Create 11/02/98 Last	3. Well Type 1 = New 2 2 = Replacement 3 = Reconstruction of previous unique well # _____ constructed in 19__ Reason for new, replaced or reconstructed well? HIGH ARSENIC	
4. Well serves 1 # of homes and/or HOMES (Ex: barn, restaurant, church, school, industry, etc.)		High Capacity: FM Well? N Property? N	1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other	
5. Well located on highest point of property, consistent with the general layout and surroundings? Well located in floodplain? N				
Distance in Feet From Well to Nearest: 1. Landfill 20 11. Foundation Drain to Clearwater 2. Building Overhang 12. Foundation Drain to Sewer 3. Septic or Holding Tank (circle one) 13. Building Drain 4. Sewage Absorption Unit 1 = Cast Iron or Plastic 2 = Other 5. Nonconforming Pit 14. Building Sewer 1 = Gravity 2 = Pressure 6. Buried Home Heating Oil Tank 1 = Cast Iron or Plastic 2 = Other 7. Buried Petroleum Tank 15. Collector or Street Sewer 8. Shoreline/Swimming Pool 16. Clearwater Sump				
6. Drillhole Dimensions From To Dia. (in.) (ft.) (ft.)		Method of constructing upper enlarged drillhole only: X 1. Rotary - Mud Circulation 2. Rotary - Air 3. Rotary - Foam 4. Reverse Rotary 5. Cable-tool Bit _____ in. dia. 6. Temp. Outer Casing _____ in. dia. Removed? 7. Other		
7. Casing, Liner, Screen Material, Weight, Specification Manufacturer & Method of Assembly		From To Dia. (in.) (ft.) (ft.)	9. Geology Type, Casing/Noncasing, Color, Hardness, Etc.	
8. Screen type, material & slot size		From To Dia. (in.) (ft.) (ft.)	10. Static Water Level ft. B ground surface A= Above B= Below	
8. Grout or Other Sealing Material		From To Dia. (in.) (ft.) (ft.)	11. Pump Test Pumping Level 160.0 ft. below ground surface Pumping at 40.0 GPM M 1.00 hrs	
		From To Dia. (in.) (ft.) (ft.)	12. Well Is: Developed? Y Disinfected? Y Capped? Y Depth (feet)	

Mailing Address SEYMOUR		City DE PERE	State WI	Zip Code 54165
County of Well Location OUTAGAMIE		Co. Well Permit No.	Well Completion Date August 24, 1988	
Well Constructor (Business Name) SCHMIDT'S WATER SERVICE		License # 6	2. Dates 09/19/88 Rec'd	
Address RT 3 BOX 27		City BLACK CREEK	State WI	Zip Code 54106
M= Munic. O= OTM N= NonCom P= Priv Z= Other X= Non-Pot. A= Anode L= Loop H= Drillhole		Create 10/10/89 Last FM	3. Well Type 2 1 = New 2 = Replacement 3 = Reconstruction of previous unique well # _____ constructed in 19__ Reason for new, replaced or reconstructed well? OLD WELL CONTAMINATED	
4. Well serves 1 # of homes and/or res (Ex: barn, restaurant, church, school, industry, etc.)		High Capacity: FM Well? N Property? N	1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other	
5. Well located on highest point of property, consistent with the general layout and surroundings? Well located in floodplain? N				
Distance in Feet From Well to Nearest: 1. Landfill 14 11. Foundation Drain to Clearwater 2. Building Overhang 12. Foundation Drain to Sewer 3. Septic or Holding Tank (circle one) 13. Building Drain 4. Sewage Absorption Unit 1 = Cast Iron or Plastic 2 = Other 5. Nonconforming Pit 14. Building Sewer 1 = Gravity 2 = Pressure 6. Buried Home Heating Oil Tank 1 = Cast Iron or Plastic 2 = Other 7. Buried Petroleum Tank 15. Collector or Street Sewer 8. Shoreline/Swimming Pool 16. Clearwater Sump				
6. Drillhole Dimensions From To Dia. (in.) (ft.) (ft.)		Method of constructing upper enlarged drillhole only: X 1. Rotary - Mud Circulation 2. Rotary - Air 3. Rotary - Foam 4. Reverse Rotary 5. Cable-tool Bit _____ in. dia. 6. Temp. Outer Casing _____ in. dia. Removed? 7. Other		
7. Casing, Liner, Screen Material, Weight, Specification Manufacturer & Method of Assembly		From To Dia. (in.) (ft.) (ft.)	9. Geology Type, Casing/Noncasing, Color, Hardness, Etc.	
8. Screen type, material & slot size		From To Dia. (in.) (ft.) (ft.)	10. Static Water Level ft. B ground surface A= Above B= Below	
8. Grout or Other Sealing Material		From To Dia. (in.) (ft.) (ft.)	11. Pump Test Pumping Level 73.0 ft. below ground surface Pumping at 15.0 GPM 8.00 hrs	
		From To Dia. (in.) (ft.) (ft.)	12. Well Is: Developed? Y Disinfected? Y Capped? Y Depth (feet)	

5 The Sulfide Cement Horizon (SCH) can sometimes be seen during the drilling of the well. Drillers often report it on Well Construction Reports (see example). The picture shows black sand and mud being returned with the cuttings and



sometimes an oily sheen can be present also. However, the black color is not always present or noticeable.

- 6 In a subdivision, just southwest of Green Bay, water levels had declined and all the wells in the area had arsenic in the 1000 ppb range. The pH in a number of the wells was around 3. Several of the wells produced acceptable water after being deepened and lowering the pump, but only for short periods of time. All of the homes are now served by municipal water.